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Technical Report No. 210

# INVESTIGATION INTO SATELLITE WINDS-II. TREATMENT AT UKMO

by

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February 1997

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# INVESTIGATION INTO SATELLITE WINDS — II. TREATMENT AT UKMO

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**Abstract**

Observations for input into the UKMO NWP model arrive continuously via the GTS. One particular type of observation is the satellite wind, calculated from a sequence of images produced by a geostationary satellite. This observation type has more commonly been thought of as a cloud-motion wind, given that the parameter it attempts to measure is that of wind speed at a particular height level calculated from the movement of clouds. The advent of satellite winds derived from water vapour, as well as infrared and visible channels, now mean that clouds are no longer the only tracers able to be followed, and that the concept of a wind at a single level becomes even more blurred than previously. This report is the second of a set of three and was written to follow through the treatment of satellite winds at the UKMO to investigate whether they are treated in a valid and consistent manner. It includes information on observation preprocessing, quality control, assimilation and quality monitoring. A short section giving some indication of their treatment at ECMWF under the optimal interpolation assimilation scheme is also included.

Part I deals with the currently known methods of production of satellite winds from each of the geostationary satellite operators. Part III assesses the current status and quality and includes recommendations on the improvement of their use within UKMO.

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# 1 Introduction

Satellite-wind producers disseminate their derived wind vectors to the meteorological community via the Global Telecommunication System. Most data arrive in SATOB format, although more datasets are being encoded into BUFR format. Satellite winds may arrive at any time, although producers try to cluster them around the main synoptic times, in contrast to aireps, for example, which are disseminated in a more continuous manner, depending upon when measurements are taken. The treatment of satellite winds at the UKMO is shown in schematic form in Fig. 1.

# 2 NMC Intervention

The information given in this section was obtained from Bob Owens, Deputy Chief Forecaster, NMC.

Before the model starts to run, all observational data are routed through NMC for possible rejection, correction, support and/or bogussing, although there is not enough time available to look at all the data in detail. The intervention process carried out under the auspices of the HORACE system does not provide any facility for rejection or correction of suspect observations. In these eventualities, a bad observation can be 'suffocated' by multiple bogussing of winds that are considered more valid, and a correctable observation can be supported by bogussing of observations with the corrected parameter. More reliance is placed on quality control (QC) than previously.

The intervention technique is facilitated by the superposition of observational data on a background field at a suitable pressure level. Any observation that is significantly different from background is flagged for the attention of the interventionist. Attention must be paid to the possible discrepancy in pressure level with regard to the observation. Information from the observation can be displayed for comparison with the values expected, so it can be seen if the major observation–background difference occurs in temperature or wind speed or wind direction. For satellite wind data, an observation is flagged for attention if either temperature or wind speed deviates significantly from the model. Before the advent of HORACE, the interventionist had the power to:

- *reject* an observation if considered totally unreliable
- *correct* an observation if it had been obviously coded wrongly
- *support* an observation not in agreement with the model but which the interventionist felt contained useful information in regions where the model was not so accurate. This has the effect of increasing the threshold allowed before rejection of the observation in QC
- *bogus* other observations in regions where the model did not seem representative of the atmospheric situation in order to pull the initial analysis field into the required shape. This had the effect of creating 'buddies' and is a particularly useful technique for defining tropical cyclones (NMC upper-air bogus obs are not used in the buddy check; see later)

Satellite winds could be rejected, supported or bogussed, but not corrected.

Written NMC guidelines used in assessing the quality of satellite winds, with a view to possible intervention are:

- if $\mid \Delta T \mid > 5^{\circ}$ reject, since this is considered indicative of bad height assignment

- if $\mid \Delta T \mid < 5^{\circ}$ check the background field and satellite imagery for any sharp temperature discontinuity. Check the time of the satellite wind vs the time of the background field: could there have been movement in the intervening period? Check other observation types in the vicinity: are radiosondes/aireps in agreement with the satellite wind? Make reject/accept/support decision based on knowledge acquired

- if $T_{satellitewind} > T_{bkgnd}$ and $V_{satellitewind} < V_{bkgnd}$, reject, since this is considered indicative of bad height assignment

- if $T_{satellitewind} > T_{bkgnd}$ and $V_{satellitewind} > V_{bkgnd}$, tend to accept the satellite wind, especially in data sparse areas and near jets, since this will help to stop the model from winding down high-speed winds. If satellite imagery enforces the satellite wind, support and bogus the data

The perception of satellite winds in NMC is that they tend to cause more problems than they solve, especially with regard to underrepresentation of speed and the problems connected with height assignment (which is typically represented by a height that is too low). They are treated with wariness and are the least trusted observation type. Some of this may be a historical carryover from the time when satellite winds were less accurate than now, however it was reported that no improvement had been noticed in the past few years, even though quality monitoring indicates that there has been noticeable improvement. NMC do not intervene for low-level satellite winds.

However, satellite winds are appreciated in certain situations: (1) in areas of tropical storm outflow, where they are most often the only data source; (2) in data sparse regions; (3) they can add weight to satellite imagery by reinforcing a situation; (4) if they show a speed that is greater than the background field. General criticisms of satellite winds from NMC are: (1) height assigned tends to be too low; since (2) temperatures tend to err on the warm side; (3) timing of the wind compared with the model run needs to be taken into consideration; (4) the underrepresentation of speed in jet regions tends to slow the model down; (5) when they go wrong they tend to be wrong in localized batches.

No use is made of any extra information on satellite winds, such as which producer they come from, what channel was used in the derivation, relative accuracies of level and location of a particular wind. ECMWF do not employ any intervention at all, although NMC state that intervention is shown to have particular benefit in short-range forecasting.

# 3 Observation Preprocessing

This is the first step in the automated NWP system, preparing the observational data for quality control. The following information is taken from Dumelow (1995). The main functions of observation preprocessing are:

- to extract data from the Met DB/Synoptic DB

- to carry out conversions of observed quantities into those required by the QC and assimilation scheme, e.g. satellite winds are coded on the GTS in satob format as wind speed and direction; the current assimilation scheme requires the data in component form, which is a straightforward calculation. Pressure level is already assigned
- to apply corrections to observational data (not relevant for satellite winds)
- to accumulate information for archiving in the Observation Processing Database (OPD)
- to set data use flags, initial probability of gross error and observation error values
- to obtain estimates of background-field error at the observation positions

The application of corrections to observational data and setting of data-use flags is done via station lists that may be easily edited, but these are not used for satellite winds. Data-use flags may be applied to individual elements within reports, specific types of reports or over whole geographical regions and can also be applied to satellite winds. Subject to recommendations from Observation Monitoring (OM), certain types and areas of satellite wind data are "blacklisted" (see Table 1), and so these data are flagged and rejected before even being considered for assimilation into the UM. OM monitor continuously the quality of the data coming in from the GTS and thus can respond quickly (generally within 24 h) if highly suspect data is being transmitted.

*Observation errors*

Most meteorological measurements contain a contribution from scales which are too small to be resolved by NWP models. Theoretically, the smallest scale the model can resolve is twice the grid length (approx. 200 km for the global model), but this also applies in the vertical. The small-scale roughness, which is sampled by the observations but which the model is incapable of representing, is termed the representativeness error. For most observations, the assimilation deals with the representativeness error (which can be estimated) by incorporating it into the overall observation error (observation error variance=instrument error variance + representativeness error variance) and weighting the impact of the observation in proportion to the inverse of the observation error variance. However, for satellite winds the representivity problems are not as severe as for other observations (setting aside height assignment problems) since the observing technique implies that a volume measurement is provided which is comparable to the model resolution. Observation errors for satellite winds are mainly derived from monitoring of observation – background differences (taken from the OPD). However, literature relevant to satellite winds (e.g. Wind Workshops and similar conferences) is also scrutinized. At present, the observation errors (rms errors in wind component) vary from 1.8 m/s for low-level satellite winds to 5.0 m/s for high-level satellite winds (see Ingleby and Parrett, 1996, Appendix 1; reproduced here as Table 2). These figures are errors in a single u or v component, and are not synoptically dependent.

*Background-field errors*

The rms errors of the background (forecast) field are estimated (Dumelow, 1995). These estimates are synoptically dependent, being larger in the vicinity of fast-moving vigorous depressions than in large anticyclones, for example. There is also a climatological element to the background-error fields in that latitudes having large numbers of observations will generally have lower error values than data-sparse latitude zones. Wind error is taken to be a function of the wind speed. Large background error estimates imply that automatic QC has less strict limits and also that the observations have more weight in the analysis. Essentially, this assigns probabilities that the winds may be wrong when compared with the model before they are compared with the model. This leads to southern hemisphere winds, for example, being flagged as more likely to be correct even if significantly different from the model, as the model is regarded as being less accurate in that particular region. The algorithms that relate the background error to components of the synoptic situation are 'trained' using the monitoring data. The background errors are interpolated to the observation positions and used in both QC and assimilation.

*Initial probabilities of gross error*

The initial probabilities of gross error (PGEs) for observations are fixed and assigned to the observation type before it is assessed individually. The initial PGEs for wind speed at the moment are 0.03 for Meteosat data, and 0.08 for all other satellites. Essentially, they are a measure of the proportion of 'bad' observations.

*Interpolation methods*

In order to obtain the difference from background values required for the QC checks, values of model variables are required at the observation locations; this may require both horizontal and vertical interpolation of background values. Background-error values are required to calculate the weights given to observation in the assimilation scheme, and are obtained from a regular grid of values by vertical and horizontal interpolation. Vertical interpolation from an observation error profile, specified on standard pressure levels (e.g. Ingleby and Parrett, 1996, Appendix 1) is also required to obtain observation errors on observation and model levels. Details of interpolation methods used can be found in Dickinson (1991).

All the data received on the GTS undergo the QC procedure, even those data that are blacklisted as not being acceptable for use regardless of their differences from the background field. The data are initially assigned a PGE=PGE0 (initial probability of gross error).

# 4 Quality Control

For full details of the QC methods employed at the UKMO, see Ingleby and Parrett (1996); the techniques are summarized here. The QC system is based on the Bayesian probability theory — it combines the results of different tests and makes an

accept/reject decision when all checks have been performed. In the UM, the calculation of background-error estimates has been separated from the QC and produces smoothed fields of background errors (during the preprocessing stage; see earlier). The initial PGE is updated by internal consistency checks (although not for satellite winds since they do not contain any redundant data, unlike synops or sondes, for example). These are followed by checks against the model background and other nearby observations (buddy checks). Only after all stages have been completed is a decision taken on whether to use the element or not, with observations having a final PGE $> 0.5$ being flagged as rejected data.

The tasks of the QC system are:

- to calculate differences between observed values and background values obtained from a short model forecast
- to check the observations against their nearest neighbours

Observational accuracy and background accuracy are used to determine the weight of an observation over the background. Improper prior specification of the observational error will therefore lead to a wrong assessment of the value of the observation and therefore to an inferior analysis.

## 4.1 Background check

The background check calculates differences between observed values and background values obtained from a short model forecast (T+3 or T+6).

Before the background check, NMC-supported elements have their PGE reduced and total error variance changed to represent the fact that NMC bogus and support the observations in areas of large background error where observations appear to be providing more reliable data. This also applies to NMC support for satellite winds. These modified variances are used within the background check only, and not within the buddy check or assimilation.

In the background check, observations are assumed to be either good (with Gaussian errors) or bad (with gross errors). The variance of observed minus background values makes the assumption that observation and background errors are uncorrelated.

Errors in u and v are assumed to be independent of one another and normally distributed with the same component variance. The PGE in location is calculated and includes any gross error affecting the whole observation. (It includes an estimate of the probability that the whole observation is wrong, e.g. position reported wrongly — there is a fixed PGE for location depending upon the individual satellite.) It also gives a dependence, if we choose, on the temperature and O–B difference that is used for checking the height assignment. However, we must be certain that we know waht temperature is input to the GTS by the wind producer. The overall probability density of the observed wind speed is calculated (fixed at 0.043 $(\mathrm{m/s})^{-1}$ for satellite

winds, i.e. independent of the background value), and based on vector differences from background, rather than considering speed and direction separately. All non-missing elements are subject to the background check to facilitate the monitoring of data not used operationally.

## 4.2 Buddy check

Excluded from the buddy check are elements that NMC reject and elements with very large deviation from the background. Checks are made of pairs of the same observation type; a preliminary step sorts the observations by position in order to facilitate the search for close pairs of observations. The search takes place over latitude and longitude bands, starting from the position of the initial observation, with subsequent bands being searched if no 'buddy' is found in the nearest bands. It compares each observation against up to about 12 neighbouring observations with a range limit of 400 km. For each pair, the background error correlation between the two positions is calculated and used to find the joint probability of the observations assuming they are both correct. This 'agreement' combined with the previous PGEs gives a factor that is used to multiply the current PGEs of both observations. The most up-to-date PGEs are used in the calculations, which makes the results dependent on the order of buddy checks to some extent. It can be thought of as a background check considering two observations simultaneously, since it compares differences from background, rather than the observed values themselves. For wind data, the wind differences from background are transformed into components along and perpendicular to the line joining the pair.

In contrast with buddy checks for some other forms of observation, the observation errors of most satellite winds are not independent of one another, since most wind vectors in a particular region come from the same source. The potential exists, therefore, for a large batch of 'bad' data to pass the buddy check and be assimilated into the model. It is hoped that the background check would be sufficiently stringent to prevent the possibility of this happening.

## 4.3 Asymmetry check

Peculiar to satellite winds is an asymmetry (speed bias) check — satellite winds which are weaker than background have their PGEs increased by a set amount dependent upon the difference between background and observation. The typical limits (which vary with background-error estimates) for a satellite wind of 250 mb at which the PGE (background) goes over 0.5 are (under current error values):

for O–B speed $\geq$ –3 m/s

Meteosat: 23.1 m/s; other: 20.7 m/s

for O–B speed $\leq$ –7 m/s

Meteosat: 18.9 m/s; other: 15.0 m/s

Although QC has already been performed by the producer, it seems wise to perform independent checks, since now we can assess the compatibility of the winds with the UKMO model, rather than with the model used by each producer both to check, and in the production of, the disseminated winds. It also allows for a more up-to-date (therefore, better) background field for QC. QC of the disseminated winds takes less than a minute, and is fully automated. Approximately 3–5 % of winds are flagged as being unacceptable against background, depending upon the satellite and the level.

In particular, the NESDIS method of height reassignment using the auto editor is not liked, since it introduces even more information from another forecast system into the observations. NESDIS supply on the GTS the original brightness temperature of the wind which was subsequently reassigned to a different pressure. The original temperature is checked against the temperature of the background field at the pressure level to which the satellite wind has been reassigned, and if the difference between the model temperature and the satellite wind temperature is greater than about 8° C, the observation will be rejected. Approximately 20–30 % of high-level GOES satellite winds are rejected in this way.

# 5 Data Assimilation

A number of documents exist detailing the scientific and technical aspects of assimilation of data into the UM (e.g. Bell *et al.*, 1996). At present, the analysis correction (AC) scheme is in use at the UKMO. The DA scheme adjusts the model state towards observations, providing initial fields for forecasts; observational data is assimilated by an iterative or 'nudging' procedure which is carried out at each time step of a separate model integration before and after the nominal analysis time. Observations for T – 3 to T + 3 are allowed, and (global model) assimilation takes place from T – 6 to T + 4. The analysis increments required to nudge the model state towards the observations are computed from the observational increments weighted by a factor depending on their displacement in space and time, and on the observational density and error. Additional balancing increments are also calculated. The repeated insertion assimilation method ensures that modes of the model with periods longer than that of the data insertion are preferred, since the atmospheric motions that we wish to forecast are usually slowly varying. In combination with balance relationships in the analysis, repeated insertion achieves simultaneous consistency between the observations and a slowly varying state of the model; it is not necessary for consistency to be achieved within one step, it is sufficient to move the model towards consistency. Since QC has already been carried out, it is assumed at the analysis stage that the distribution of observational errors is approximately Gaussian. More detailed explanation is given in Bell *et al.* (1996).

Lunnon and Lowe (1991) suggested ways to improve the method used to interpolate the received CMWs into the limited area model of the UKMO — alternative ways of performing horizontal, vertical and temporal interpolation. They concluded that there was room for significant improvement in the operational interpolation method, by using temperature as the vertical coordinate, corrected time values (since the nominal time of a satellite wind is not the correct time at a particular latitude since

scanning the disk from south to north takes a finite amount of time) and weighted means in the horizontal. This procedure was not implemented, as it was not suitable for global runs; the total impact was estimated to be fairly minor.

# 6 Observation Monitoring

Once the assimilation is complete, monitoring information is put back into the Met DB, and the Observational Processing Database (OPD) is produced. The OPD contains details of the initial raw observation data from the GTS; their differences from background (3- or 6-hour forecast) and analysis; and quality flags (either from prior QC or if the data were subsequently rejected; plus any information from NMC checks) and support data. The OPD is used for investigations into observation or forecast quality, and for monitoring the performance of the QC and analysis systems. These include both extended period statistical investigations and case studies. From the data on the OPD, Observational Monitoring takes place continuously, allowing the updating of observation quality statistics for feedback into the system, alerting us to deficiencies in the observing system or to possible deficiencies in the model.

At present, routine satellite wind monitoring at the UKMO is carried out on a daily basis and inspects the number of observations coming in from each satellite/channel combination; the mean O–B windspeed; the rms O–B vector wind error; the percentage of background flagged data, i.e. the data that fail the check against the UKMO model background field; and the percentage of final flagged data in total, i.e. after any other QC procedures and including blacklisted winds. Statistics are kept on daily, weekly and monthly bases. Specific quarterly monitoring notes used to be produced until recently (e.g. Leighton, 1995). These were quarterly results for satellite-derived temperatures and winds compared with similar statistics from non-satellite observations.

Certain satellite-wind data are rejected or "blacklisted" based on their quality ascertained from continuous monitoring. The blacklisted data and regions are changed as wind producers alter their procedures, e.g. change software or move to a new operational satellite. At the beginning of 1996, UKMO did not use any winds other than those derived from IR imagery, and only then in certain areas and levels. Throughout the first half of 1996, Observation Monitoring have unblacklisted certain Meteosat WV and VIS winds. For the current blacklisted data and areas, see Table 1. INSAT data are routinely blacklisted since the quality of the data is not yet considered good enough. However, it is slowly improving due to increased user/producer interation at the wind workshops, for example. Low-level wind data over land are generally not used due to the fact that adequate and more accurate alternative observations exist (e.g radiosondes) in these regions. All types of winds from Meteosat are used, but blacklisted in certain locations. WV winds from GOES and GMS are not assimilated as they are produced in regions of clear air. GMS VIS winds have been assimilated for many years as initially they were placed on the GTS without an identification and assumed to be IR CMWs. Australian winds extracted from GMS imagery are not monitored as they are not available on the GTS.

# 7 Treatment at ECMWF

## 7.1 Blacklisting

ECMWF operate a blacklist but with different delineations from the UKMO blacklist. Information supplied by M. Tomassini and from ECMWF data assimilation scientific documentation show the default operational usage of satellite winds to be:

Not used:

- over land north of 20 °N
- over land and below 500 hPa south of 20 ° S

Satellite wind types excluded completely are:

- Meteosat IR medium-level winds
- All INSAT winds
- All GMS WV winds
- GOES WV medium-level winds (high-level GOES WV assimilated since December 1996)

Exceptions to the above policy are:

- High-level IR and WV Meteosat winds are assimilated over land in N. Africa (20-35 °N)
- High-resolution Meteosat VIS winds are assimilated at 12Z (since December 1996)

## 7.2 Quality control

Under OI. QC at ECMWF consisted of checks of code formats, internal consistency checks on the data within one observation, temporal consistency checks on observations from the same source, check against climatological values, checks agains forecast values, checks against analysed values. Each observation carried with it a flag recording the results of the checks so far. When the comparison against a first-guess field is carried out, an observation is flagged if its squared deviation is greater than a predetermined multiple of its estimated variance. Limits used under OI for wind speed were: 8, 18 and 20 m/s to be flagged as probably correct, probably incorrect and incorrect, respectively. However, these limits were multiplied by 0.1 for satellite winds except at low levels. An additional asymmetry check was carried out for satellite winds, applied whenever the observed wind speed was more than 4 m/s slower than

the first guess wind speed. In this case, the limits were decreased further, being multiplied by 0.15 for low-level winds, by 0.07 for tropical medium- and high-level winds, and by 0.075 - 0.00125 $\times$ the magnitude of the first-guess speed for extratropical medium- and high-level winds.

For the case of wind data, a wind direction check was carried out. If the observed direction differed by more than 60, 90 and 120 ° from the first-guess wind direction, it was flagged as probably correct, probably incorrect and incorrect, respectively. This check was applied to upper-air winds above 700 hPa and for wind speeds greater than 15 m/s.

Table 3 shows the standard deviations of satellite wind observation errors applied at ECMWF under both the OI and 3DVAR (from 30/1/96) assimilation schemes. These can be compared with those applied at UKMO shown in Table 2.

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FIGURE CAPTIONS

**Fig. 1.** Flow chart of satellite wind treatment at UKMO.

**Table 1.** Current UKMO satellite wind two-level blacklist.

**Table 2.** RMS component wind errors for satellite winds at model levels; UKMO (Ingleby and Parrett, 1996)

**Table 3.** SD of observation errors for satellite winds under OI and 3DVAR; ECMWF (Pers. commun., M. Tomassini)

Fig. 1. Flow chart of satellite wind treatment at UKMO.

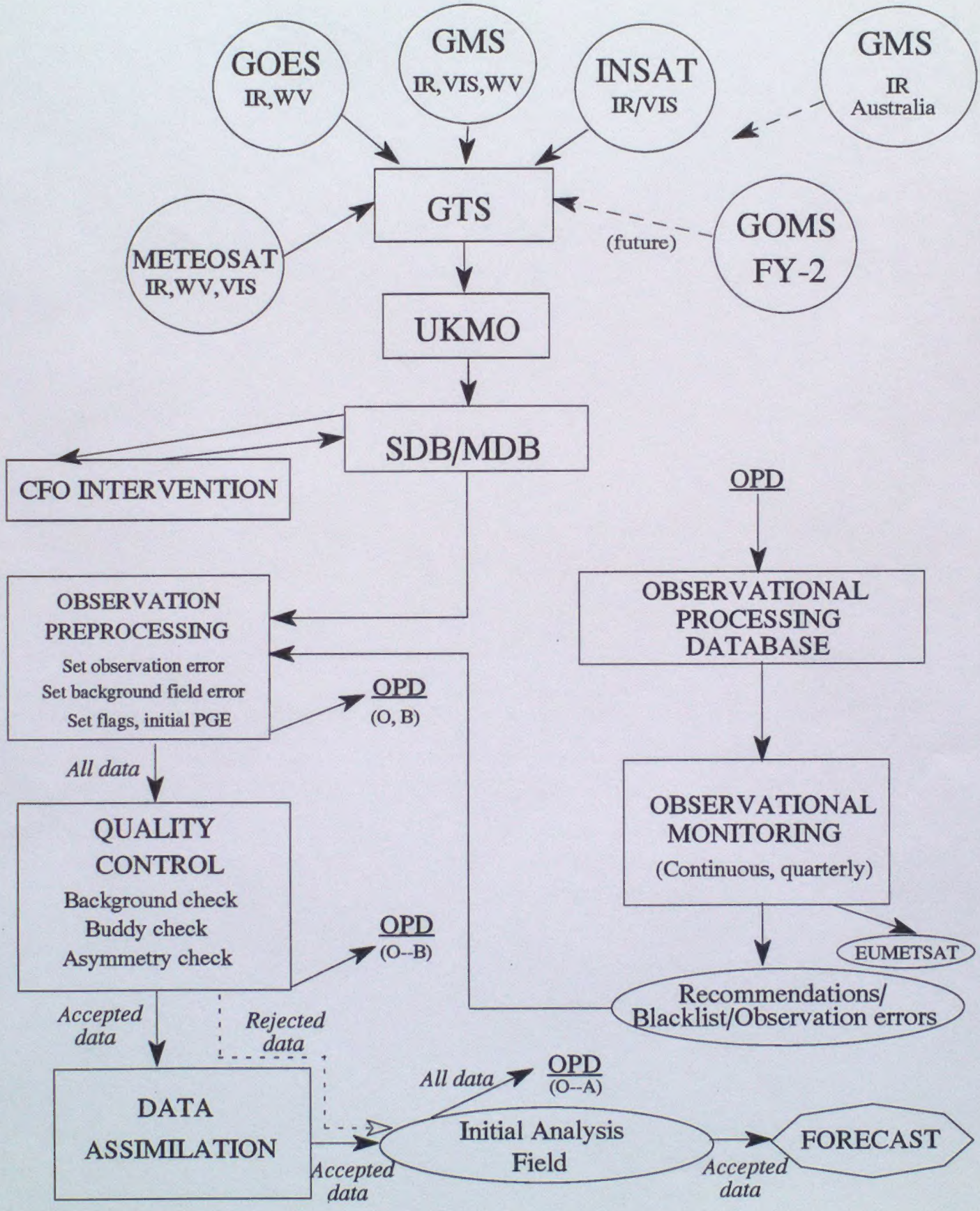

**Table 1.**
**UK MET OFFICE BLACKLISTED SATELLITE WIND DATA; 2/7/96 change**
X=blacklisted

| | | MET_IR | | GOES8_IR | | GOES9_IR | | GMS_IR | | INSAT_IR | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | HL | LL | HL | LL | HL | LL | HL | LL | HL | LL |
| NH | LAND | | X | | X | | X | | X | X | X |
| | SEA | | | | | | | | | X | X |
| TR | LAND | | X | | X | | X | | X | X | X |
| | SEA | | | | | | | | | X | X |
| SH | LAND | | X | | X | | X | | X | X | X |
| | SEA | | | | | | | | | X | X |

| | | MET_WV (cloudy)+ | | GOES8_WV | | GOES9_WV | | GMS_WV | |
|---|---|---|---|---|---|---|---|---|---|
| | | HL | LL* | HL | LL | HL | LL | HL | LL |
| NH | LAND | | | X | X | X | X | X | X |
| | SEA | | | X | X | X | X | X | X |
| TR | LAND | | | X | X | X | X | X | X |
| | SEA | | | X | X | X | X | X | X |
| SH | LAND | | | X | X | X | X | X | X |
| | SEA | | | X | X | X | X | X | X |

| | | MET_VIS(half-res) | | MET_VIS(full-res)# | | GMS_VIS | |
|---|---|---|---|---|---|---|---|
| | | HL* | LL | HL | LL | HL | LL |
| NH | LAND | X | X | X | X | X | X |
| | SEA | | | X | X | | |
| TR | LAND | X | X | X | X | X | |
| | SEA | | | X | X | | |
| SH | LAND | X | X | X | X | X | X |
| | SEA | | | X | X | | |

Notes: NH=north of 20 N, TR=20 N - 20 S, SH=south of 20 S; HL= 0 - 500 hPa, LL= 500 - 1000 hPa; LAND, SEA= over land or sea, respectively; *=no such data normally available; #=not in satob code; +Meteosat clear-air WV winds not used in model, not in satob code.

v3a/30/1/97

**Table 2.** RMS component wind errors for satellite winds at model levels; UKMO (Ingleby and Parrett, 1996)

| Pressure (hPa) | 70 | 100 | 150 | 200 | 250 | 300 | 400 | 500 | 700 | 850 | 1000 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| RMS conpt wind errors (m/s) | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 4.6 | 4.0 | 2.1 | 1.9 | 1.8 | 1.8 |

**Table 3.** SD of observation errors for satellite winds under OI and 3DVAR; ECMWF (Pers. commun., M. Tomassini)

| Pressure (hPa) | 10 | 20 | 30 | 50 | 70 | 100 | 150 | 200 | 250 | 300 | 400 | 500 | 700 | 850 | 1000 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SD; OI (m/s) | 6.0 | 6.0 | 6.0 | 6.0 | 6.0 | 6.0 | 6.0 | 6.0 | 6.0 | 6.0 | 6.0 | 6.0 | 3.0 | 3.0 | 3.0 |
| SD; 3DVAR (m/s) | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 4.3 | 3.5 | 2.0 | 2.0 | 2.0 |